UNIT IV

CANAL IRRIGATION

PART A

1) What are the classification of canals based on nature of source of supply? **(AU MJ 2008)**

- .Permanant canal
- .Inundation canal

2) What are the classification of canals based on financial aspect? **(AU MJ 2008)**

- Productive canal
- Protective canal

3) What are the classification of canals based on function served by the canal? **(AU ND 2008)**

- Link canal
- Feeder canal
- Power canal

4) Why the canals are aligned? **(AU ND 2008)**

Water should reach the land by gravity .To accomplish this requirement irrigation canalalways aligned in such a way that the water gets proper command over the wholeirrigable area.

5) What are the methods of alignment? **(AU MJ 2009,2012)**

- Alignment of contour channels
- Alignment of ridge or watershed channels
- Alignment of side slope channels

6) Write any two factors to be considered while aligning the canal. **(AU MJ 2009)**

- The canal should be aligned on the ridge.
- Canal alignment should be kept in the centre of the commanded area.

7) What is cross drainage work? **(AU ND 2009)**

A cross drainage work is a structure carrying the discharge of a natural stream across acanal intercepting the stream.

8) What are the types of cross drainage works? **(AU ND 2009,MJ2011)**

- C.D works carrying canal over the drainage
- C.D works carrying canal over thecanal
- C.D works admitting the drainage water into the canal

9) What is canal head works? **(AU MJ 2010,ND2011)**

When a permanent canal system is taken off from the river some works are to beprovided at the off take to care of irregularities in river flow condition.Since these worksare constructed the point of take off,that is at the head of the canal system they aretermed as canal headworks.

10) What is diversion headworks? **(AU MJ 2010,MJ 2011)**

The main object of the canal headworks is to divert the water from the river into thecanal.So it sometimes termed as diversion headworks.

11) Where the canal headworks are located? **(AU ND 2010,ND2011)**

The canal headworks are located in the sub-mountainous stage.

12) What are all the considerations needed before selecting the canal headworks? **(AU ND 2010)**

- Economical considerations
- Functional considerations
- Structural considerations

13) What are all the components of canal headworks? **(AU MJ 2012)**

- Weir or an anicut
- Divide wall
- Under sluices or scouring sluices
- Fish ladder
- Head regulator for a canal
- Silt exclusion device
- River training works

14) Differentiate between a weir and the barrage. **(AU MJ 2012)**

Barrage: It is a low obstructive barrier constructed across the river.Gates are provided on the crest of the barrier.

Weir : All small obstructions are simply termed as weirs.The obstructions may befalling shettres or trained gates or drum gates.

15) Why training works are provided? **(AU ND 2012)**

When a river is very wide some training is to be done before constructing the headworks.The aim of training works is to induce the flow of water along the desired bank or channel without causing abrupt changes.Generally guide banks,marginal bunds andsometimes spurs are provided for the purpose.

PART-B

1. Describe in brief different types of river training works? **(AU MJ 2008,ND2012)**

‘River training’ refers to the structural measures which are taken to improve a river and its banks. River training is an important component in the prevention and mitigation of flash floods and general flood control, as well as in other activities such as ensuring safe passage of a flood under a bridge. For flash flood mitigation, the main aim is to control the water discharge regime in the watercourse by limiting its dynamic energy, thereby controlling the morphological evolution of the watercourse (Colombo et al. 2002). River training measures also reduce sediment transportation and thus minimize bed and bank erosion. Many river training structures are implemented in combination with bioengineering techniques to lessen the negative effects on environment and landscape (see Chapter 3). There are a number of types of river training structure. The selection and design of the most appropriate structure depends largely on the site conditions. River training structures can be classified into two main categories: transversal protection structures and longitudinal protection structures.

Transversal Protection Structures Transversal protection structures are installed perpendicular to the water course. They are used to lower the river gradient in order to reduce the water velocity and protect the river bed and banks from erosion. Most of the rivers in the Hindu Kush Himalayan region originate in the high mountains, where they have steep gradients giving the flow a massive erosive power. Moreover, intense rainfall and breakout events can accelerate the river flow to such an extent that the water has a significant impact on the watercourses and surrounding areas. Transversal protection structures are effective for controlling the velocity of rivers and streams and reducing the development of flash floods. The major structures likely to be useful in the region are described briefly in the following.

Check dams Check dams are described in detail in the previous chapter, mainly in relation to gully control. The dams used along river courses follow the same principles. They can be made of gabions, concrete, logs, bamboo, and many other materials. These dams decrease the morphological gradient of the torrent bed and reduce the water velocity during a flood event by increasing the time of concentration of the hydrographic basins and reducing the flood peak and solid transportation capacity of the river. They also help to reduce erosion and debris flow. The main purpose of check dams on rivers is to stabilize the riverbed over a long distance. Check dams generally require additional protection structures in the bed or on the banks to hinder undermining.

Spurs A spur, spur dyke, or groyne is a structure made to project flow from a river bank into a stream or river with the aim of deflecting the flow away from the side of the river on which the groyne is built. Two to five structures are typically placed in series along straight or convex bank lines where the flow lines are roughly parallel to the bank (McCullah and Gray 2005). Spurs help train a river to flow along a desired course by preventing erosion of the bank and encouraging flow along a channel with a more desirable width and alignment (Julien 2002). They are used to control natural meandering at a river bend, to channel wide rivers, and to convert poorly defined streams into well defined channels. The spurs create a zone of slack flow which encourages silting up in the region of the spur to create a natural bank. They generally protect the riparian environment and often improve the pool habitat and physical diversity. Spurs can be made from many materials including stone, for example in the form of gabions (Figure 42) or in bamboo ‘cages’ (Figure 43); tree trunks and branches (Figure 44); concrete; or any material that is not easily detached by the river and is strong enough to withstand the flow and the impacts of debris. They can be categorized on the basis of permeability (Figure 45), submergence (Figure 46), orientation (Figure 47), and the shape of the head (Figure 48). Some guidelines for designing and constructing spurs are provided in Box 16. Sills A sill (also called a bed sill or ground sill) is a transverse gradient control structure built across the bed of a river or stream to reduce bed or headward erosion. Sills are installed along river stretches with a medium to low morphological gradient. The purpose is similar to that of a check dam, but a sill is much lower. A sill is usually constructed together with other hydraulic structures such as bridges to prevent them from being undermined and increase their durability. Sills can be built with different shapes, for example stepped or sloping, and from a variety of materials including concrete, stone, gabions, wood, and rock. The selection of material depends on morphological and ecological factors. Sills made from wood, rock, and gabions tend to be more environmentally friendly than those made from concrete or cemented stones.

Concrete or stone sills. Sills made of concrete or concreted stone are easy to construct and relatively common, even though the construction cost is generally higher than for other types. This type of sill can be used for a wide range of morphological conditions, and is particularly suitable for lower reaches. They are often used in combination with structures such as bridges or walls.

Gabion sills. Sills made with gabions can be installed under many different hydrodynamic conditions. The gabions can be filled with rock from along the river or stream bed. Gabion sills are considered environmentally less harmful than concrete sills for the natural riverine environment and ecology because of their greater width and limited height.

Wood and rock sills. Sills are often made of local wood and rock in the mountainous reaches of watercourses or at sites with morphological constraints. Any kind of water resistant wood can be used, the most suitable being chestnut, larch, and natural or treated resinous plants. This type of sill has a low environmental impact because of its tendency towards naturalization, which favours the ecology and environment of the watercourse

2 What is mean by guide banks? What are their functions and effects? **(AU MJ 2009,ND2010)**

Guide Banks

Also called Bell's bund. It is defined as the site of a barrage, weir, bridge, ect. To guide the river flow through the confined waterway without causing damage to the structure and its approaches. They are provided in the direction of flow, both upstream and downstream of the barrage of one or both flanks depending or requirement. The guide banks are usually provided in pairs, symmetrical in plan and may either be parallel or converge slightly towards the structure, extending a little downstream but laygely on the upstream of the structure and curved inlands on both ends to provided a bellmouth entry and smooth exit. The layout of training works for a barrage, weir or bridge are almost identical and consist of a pair of guide banks and armoured groynes. The guide banks are two heavily armoured embankments in the river in the from of a bellmouth figure. Simple approach embankments span the portion of the river between the normal river banks and the guide banks.

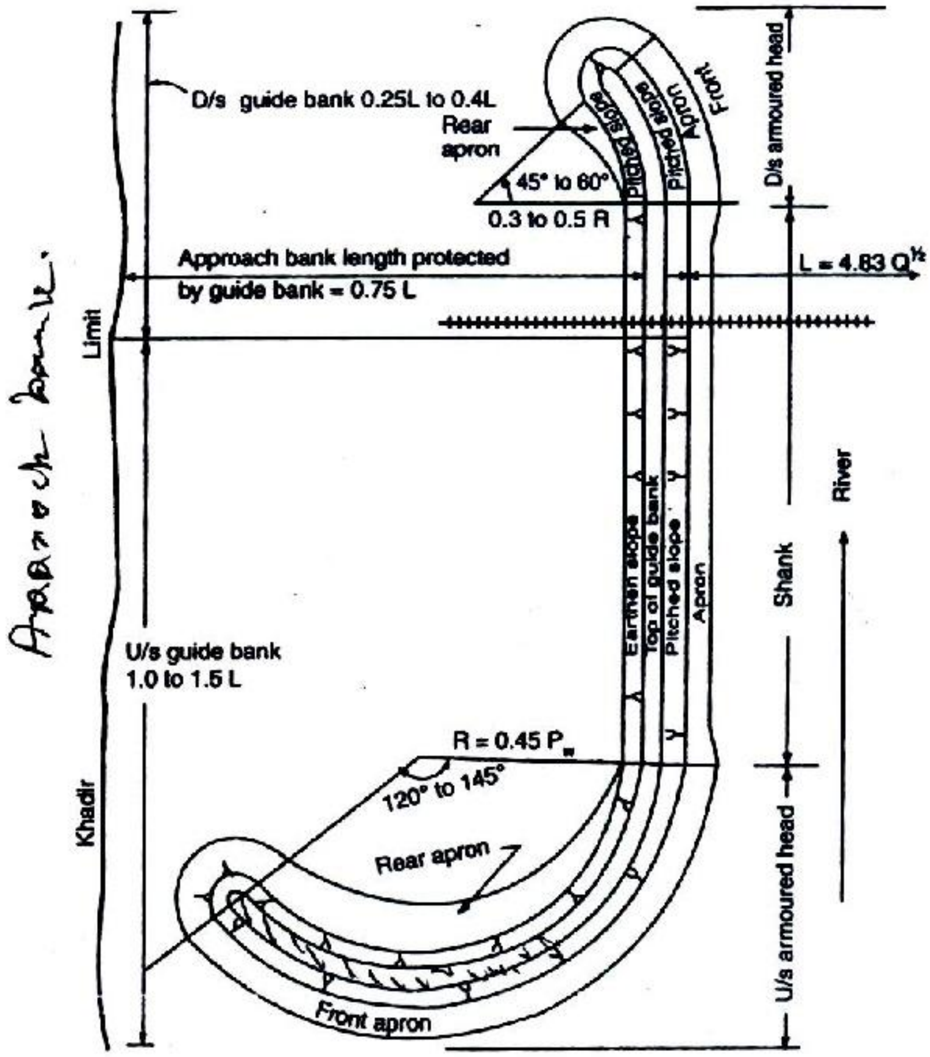


Figure: Layout of guide bank.

Functions of a Guide Bank: The functions served by a guide bank are (i) Economical spanning of a wide river, (ii) Safe and expeditions passage of floods, (iii) Protect adjacent lands, upstream of a weir or barrage from spills due to afflux caused by the barrage construction, (iv) control and confine the flow axially through a restricted waterway so that the river has no possibility to swing about and outflank the structure, (v) Prevent occurrence of crossflow immediately upstream of barrage, and (vi) Protect the approach embankments (on either side of a bridge extending from the river bank to the guide banks) from direct attack by the river.

Effects of Guide Banks: The effects of guide banks are (i) Increase in the rate at which flood wave passes down the river, (ii) Increase in maximum discharge at all points downstream, (iii) Rise in the water surface elevation of the river during flood, (iv) Increase in the velocity and scouring action through the embanked section, and (v) Reduction in water surface slope of the river above the embanked portion.

Classification of Guide Banks

1. According to Form in plan: The pair of guide banks may be parallel, divergent or convergent in plan upstream of the structure.

(a) Parallel guide banks. Where the river is likely to meander on both sides, parallel guide banks with suitable curved heads are essentially required to give uniform flow from the head of the guide bank to the work. Symmetrical and parallel guide bands figure are usually adopted unless local conditions warrant adoption of convergent or divergent banks; their suitability being indicated by model studies.

(b) Convergent guide banks: Convergent guide banks are rarely used. They have the disadvantage of excessive attack and heavy scour at the head and shoaling all along the shank rendering the end bays inactive.

Divergent guide banks. Divergent guide banks exercise an attracting influence on the flow and are indicated where approaching flow is oblique to the structure or work is located at one edge of khadir, in order to keep the flow active in the spans adjacent to them. However they provide relatively less protection to the approach embankment, under worst possible embayment Embayment. A localized widening of a river or channel brought out artificially or naturally, as compared to the equal length of parallel guide banks. The divergent guide banks thus require longer length in comparison to parallel guide banks for the same degree of protection to the approach embankment. They induce oblique flow onto the barrage and give rise to tendency of shoal formation in the centre due to larger waterway between curved heads.

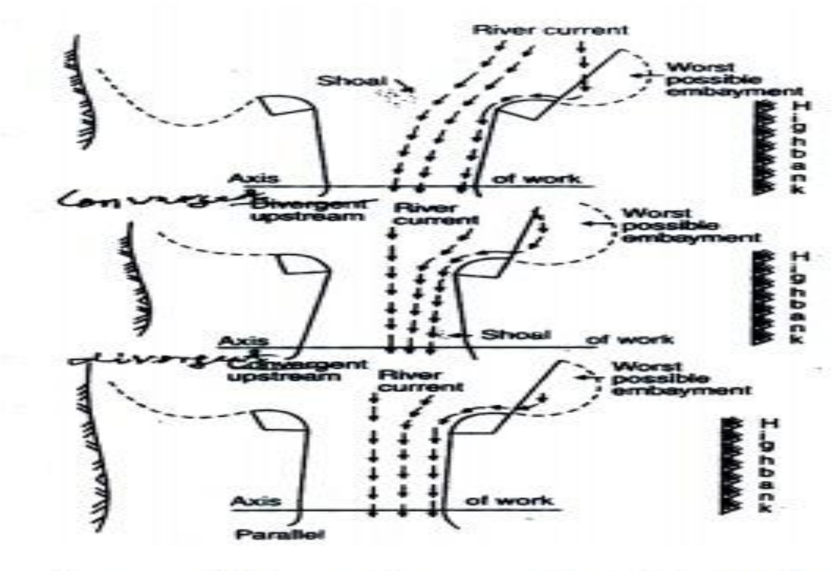


Figure: Different forms of guide banks.

Figure: Different forms of guide banks.

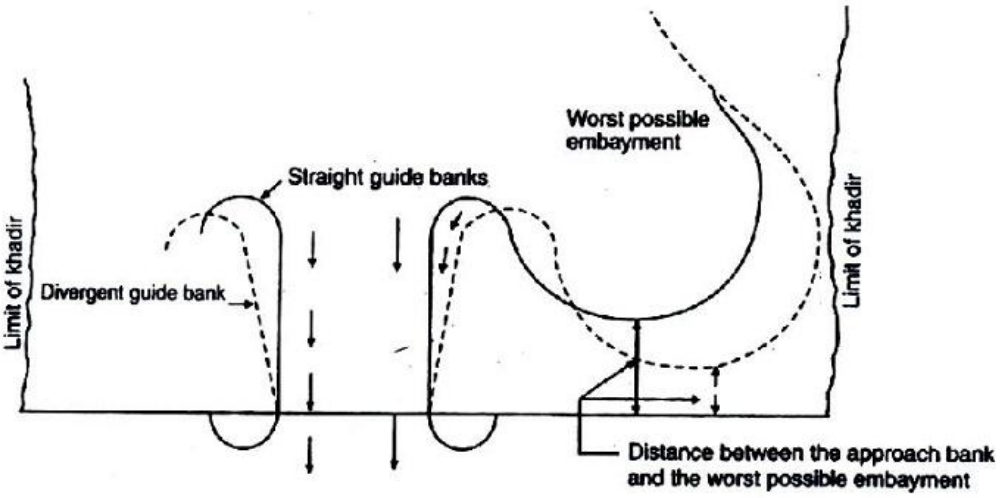


Figure: Extent of protection provided by the straight and divergent guide banks.

2. According to Geometrical Shape. On the basis of geometrical shape, the guide banks are classified as straight and elliptical with circular or multiradii curved head. Any other shape, if warranted by site conditions, is determined with the aid of hydraulic model studies.

Elliptical guide banks are preferred to the straight ones on account of the considerations (i) More suitable for wide flood plain rivers compared to straight guide banks, (ii) Flow hugs the guide banks all along their length due to gradual change in curvature, while separations of flow occurs in straight guide banks after the curved head which leads to obliquity of flow, and (iii) Provide better control on development and extension of meander loop towards the approach embankment.

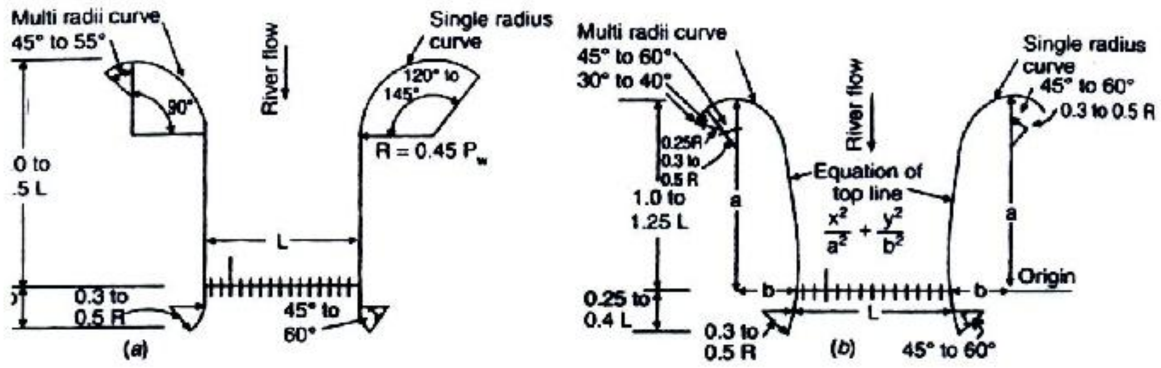


Figure: Geometrical shapes of guide bank (a) straight guide bank, (b) elliptical guide bank

3 State the necessity and location of canal falls? **(AU MJ 2010, ND2008)**

Canal fall is a solid masonry structure which is constructed on the canal if the natural ground slope is steeper than the designed channel bed slope. If the difference in slope is smaller, a single fall can be constructed. If it is of higher then falls are constructed at regular suitable intervals.

Location of Canal Falls

Location of canal fall depends upon the following factors

Topography of canal

Economy of excavation or filling

The above two will decide the location of canal fall across canal. By understanding topographic condition we can provide the required type of fall which will give good results. At the same time, the provided falls is economical and more useful. So, economical calculation is also important. Unbalanced earth work on upstream and downstream result the project more uneconomical.

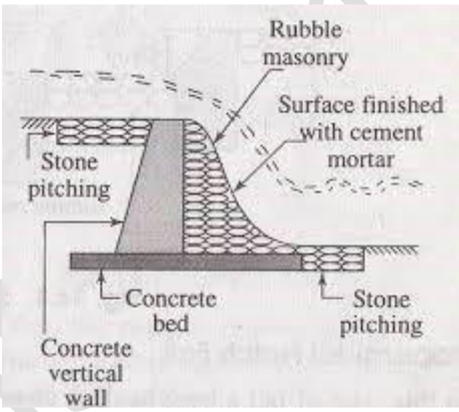
Types of Canal Falls and their Importance

The important types of falls which were used in olden days and those which are being used in modern days are described below:

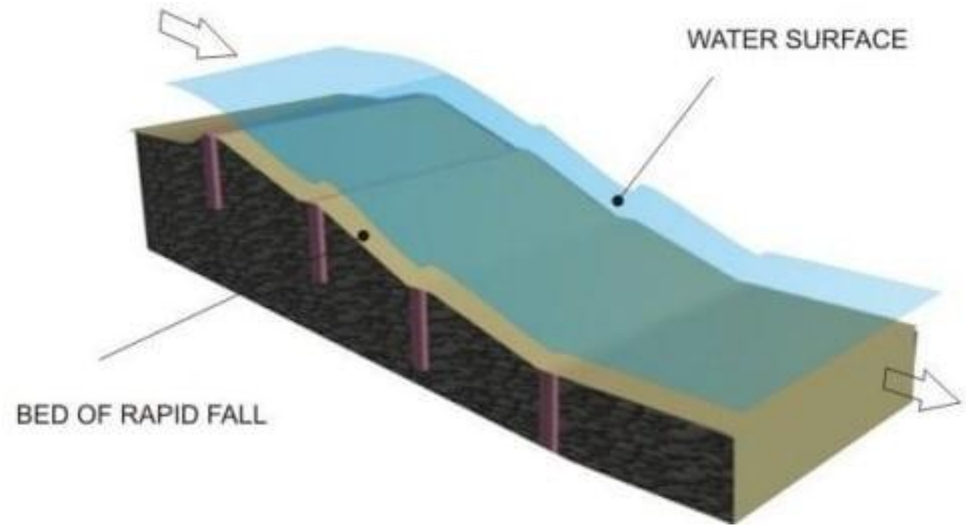
- Ogee falls
- Rapids

- Stepped falls
- Trapezoidal notch falls
- Well type falls
- Simple vertical drop falls
- Straight glacis falls
- Montague type falls
- English falls or baffle falls

Ogee Canal Falls
Ogee curve is the combination of convex and concave curves. So, Ogee fall consists of both convex and concave curves gradually. This gradual combination helps to provide smooth transition of flow and also reduce the impact. If the canal natural ground surface is suddenly changed to steeper slope, ogee fall is recommended for that canal. Stone pitching is provided in the upstream and downstream of the fall.



Rapid Canal Falls
Rapid fall consists a long sloping glacis. It is constructed if the available natural ground surface is plane and long. For this, a bed of rubble masonry is provided and it is finished with cement mortar of 1:3 ratio. To maintain the slope of bed curtain walls are provided at both upstream and downstream. Rapid falls are high priced constructions.



Stepped Canal Falls

As in the name itself, stepped fall consist vertical steps at gradual intervals. Stepped fall is the modification of rapid fall. It is suitable for the canal which has it upstream at very high level as compared to downstream. These two levels are connected by providing vertical steps or drops as shown in figure.

Trapezoidal Notch Canal Falls

In case of trapezoidal notch falls, a high crested wall is built across the channel and trapezoidal notches are provided in that wall. Trapezoidal falls are very economical and suitable for low discharges. Now a days this type of falls are using widely because of their simplicity and popularity.

Well Type Canal Falls

Well type falls are also called as syphon drop falls. In this case, an inlet well with pipe at its bottom is constructed in upstream. The pipe carries the water to downstream well or reservoir. If the discharge capacity is more than 0.29 cumecs then downstream well is preferred otherwise reservoir is suitable.

Simple Vertical Drop Falls

Simple vertical drop fall or sarda fall consists, single vertical drop which allows the upstream water to fall with sudden impact on downstream. The downstream acts like cushion for the upstream water and dissipate extra energy. This type of fall is tried in Sarda Canal UP (India) and therefore, it is also called Sarda Fall.

Straight Glacis Canal Falls

This is the modern type of construction, in which a raised crest is constructed across the canal and a gentle straight inclined surface is provided from raised crest to the downstream. The water coming from upstream crosses the raised crest and falls on inclined surface with sufficient energy dissipation.

Montague Type Canal Falls

Montage fall is similar to straight glacis fall but in this case the glacis is not straight. It is provided in parabolic shape to introduce the vertical component of velocity which improves the energy dissipation to more extent.

English or Baffle Canal Falls

In this case, straight glacis fall is extended as baffle platform with baffle wall. This is suitable for any discharge. The baffle wall is constructed near the toe of the straight glacis at required distance in designed height. The main purpose of the baffle wall is to create hydraulic jump from straight glacis to baffle platform.

4 Briefly explain about classification of canals? **(AU ND 2009,MJ 2012)**

A *canal* is an artificial waterway. The word "canal" origins from the Old French word chanel, which means "channel." Sometimes it is also known as navigation.

In ancient time, A canal is used to connect waterfalls with the intention of shortening routes. Now it is constructed to allow the passage of boats or ships inland or to convey water for irrigation, human-made strip of water used for irrigation or boat access to a more significant body of water.

A canal plays a vital role when it comes to transportation and global commerce. We use the canal for irrigation, land drainage, urban water supply, hydroelectric power generation, transportation of cargo and people, power generation, the canal is also used to connect industrial centers with ports to speed movement of raw materials. Water filled canals at high levels can deliver water to any place where there is a water crisis. However, Canals weaken the foundation of the dam.

Canals of Burano. Source- Linda D Lester

Types of Canals

We can identify different types of canals based on usage, discharge, branches, provider, alignment, etc.

Based on usage there are two types of canals:

1. Aqueducts
2. Waterways

Based on discharge there are five types of canals:

1. Main canal
2. Branch canal
3. Major distributary
4. Minor distributary
5. Watercourse or field channel

Based on provider canals can be classified into two types

1. Unlined canals

2. Lined canal

Based on alignment there are three canal types:

1. Contour canal
2. Watershed canal
3. Side slope canal

Canal Types Based on Usage

Aqueducts

Aqueduct is a significant watercourse which carries water from a source to the far distribution point. There are many versions of aqueducts. The simplest types are mostly small ditches cut into the earth. They run through underground tunnels. However, modern aqueducts use the pipeline as their path. This types of canals are used for the conveyance and delivery of water for consumption, and agricultural irrigation.

Waterways

Inland waterways canal. Source- Conway Photography

Waterways are the type used for carrying ships and boats and conveying people. Waterway paths are known as a secondary by-product of our country’s extensive historical waterway network, and their essential contribution to everyday life has mostly gone unrecognized. They include water features like river, canal, streams, as well as lakes, reservoirs, and docks. Related features of waterways include weirs, locks, rapid, etc. Waterways provide a safe operating environment by reflecting the local conditions. Mostly waterways are used for transformation, irrigation, headrace, trail race, penstock, spillway, etc. They cater to a wide range of boating and water activities as well as control of pests. Waterways act as refuges for terrestrial fauna species during times of drought and as corridors for dispersal. Waterway paths attract more commuting, tourism. It helps to decrease carbon footprints, reduce road congestion and improve the health of local communities.

Canal Types Based on Discharge

Main Canal

Canals are having discharge more significant than ten cumecs are called as main canals. The main canal is also known as the arterial canal. In drainage, the main canal is the superior canal of the drainage system; it collects water from the drainage canals and conducts it to the water intake. The main canal carries discharge directly from the river. It takes off directly from the upstream side of weir head works or dam. Usually, no direct cultivation is proposed. It supplies water from a river, reservoir, or canal to irrigated lands by gravity flow. It supplies water to a branch canal. We cannot use the main canal for direct irrigation.

Branch Canal

Halifax Branch canal. Source: pinterest.ca

Branch canals have discharge in the range of 5-10 cumecs. The branches of the main canal go in either direction at regular intervals. It offtakes from the main canal where the head discharge is not more than 14-15 cumecs. Branch canal also plays the role of feeder channel for major and minor distributaries. Branch canals do not carry out direct irrigation, but they provide direct outlets.

Major Distributary

Canals who offtake from the main canal or branch canal with head discharge from 0.028 to 15 cumecs are termed as significant distributaries. It takes off water from branch canals. Sometimes getting supply from the main canal, their discharge is less than branch canal. These are mostly known as irrigation channels because of their supply of water to the field directed through outlets.

Minor Distributary

Canals in which discharge ranged from 0.25 up to 3 cumecs are termed as minor distributors. It offtakes from a major distributary carrying discharge less than 0.25 cumecs are termed as minor distributary. Sometimes minor distributary gets supply from the branch canals. The discharge in minor distributary is less than in the major distributary. They also provide water to the courses through outlets provided along with them.

Watercourse or Field Channel

The discharge in watercourses is less than 0.25 cumecs. A field channel either take off from a significant distributary or minor- it solely depends on which extent the irrigation will happen. In a few cases, it also takes off water from the branch canal for the field. Small channels which carry water from the outlet of a major or minor distributary or a branch canals to the areas to be sprayed. There are small channels for feeding water to the irrigation fields.

Canal Types Based on the Provider

Unlined Canals

Unlined canals consist of bed and banks made of natural soil. They are not provided with a lining of impervious materials. It produces the growth of aquatic weed retards the flow which leads to massive maintenance cost. Unlined canals can tolerate velocities no more than 0.7 m/s because of erosion. In unlined canals, there is a danger of canal bank breakage caused by overtopping, erosion and animal burrowing. Weeds had severely slowed down the water flow of the canals, preventing up to 50% of the water from reaching the tail end of the canal. It also causes waterlogging of the adjacent net.

Lined Canal

Lined canals are provided with a lining of impervious materials on its bed and banks to prevent the seepage of water. The most commonly used types of padding are concrete, shotcrete, brick or burnt clay tile, boulder, concrete blocks, stone masonry, sand-cement, plastic, and compacted clay. Possible benefits of lining a canal include water conservation; no seepage of water into adjacent land or roads; reduced canal dimensions; and reduced maintenance

5 Briefly discuss the design considerations of a canal trough for an aqueduct syphon? **(AU MJ 2011,ND 2011)**

Design Principles for Aqueduct:

(i) Estimation of Design (Maximum) Flood Discharge of a Drain:

The drain to be crossed may be small or like a river. In all cases correct assessment of maximum flood or peak flow of a drain should be obtained beforehand.

(ii) Waterway Requirement for a Drain:

Lacey's regime perimeter equation gives good basis for calculating the drainage waterway. The equation is

Pw = 4.825 Q1/2

Where, Pw is the waterway to be provided for the drain at the site in metres. Q is flood discharge of the drain in m3/sec. As the piers reduce the actual waterway available, the length between the abutments (Pw) may be increased by 20 per cent. When the waterway is fixed from Lacey's regime perimeter equation, the regime condition in the drain upstream and downstream of the structure is not disturbed appreciably. To confine the drainage water to the desired waterway guide banks may be constructed.

(iii) Velocity of Flow through Barrel:

The velocity of flow through the barrel may range from 1.8 m/sec to 3 m/sec, The reason for selecting this range is that the lower velocities may cause silting in the barrels. Whereas when the velocity is higher than 3 m/sec the bed load may cause abrasion of the barrel floor and subsequently it may be damaged.

(iv) Height of Opening:

Once the waterway discharge and velocity are fixed the depth of flow may be obtained easily. There should be sufficient headway or clearance left between the HFL and the bottom of the canal bed. A clearance of 1 m or half the height of the culvert, whichever is less would be sufficient. Hence, Height of opening = Depth of flow + Clearance or headway.

(v) Number of Spans:

After determining the total length of an aqueduct between the abutments number of spans to be provided may be fixed on the basis of the following two considerations:

i. Structural strength required, and

ii. Economical consideration.

Generally fluming ratio is taken to be 1/2. This ratio is adopted m such a way that the velocity of flow in the trough does not go above critical velocity limit. Generally velocity of flow should not be more than 3 m/sec. This precaution is taken to avoid the possibility of formation of a hydraulic jump. The obvious reason is that when hydraulic jump forms it absorbs energy. In this process valuable head is lost and large stresses are produced in the structure.

Length of Contraction or Approach Transition:

Once the width at throat is fixed length of contraction can be determined after knowing the convergence ratio. The convergence ratio is generally taken as 2: 1 (horizontal: lateral), i.e., not steeper than 30°.

Length of Expansion or Departure Transition:

Length of expansion on the downstream side of the aqueduct may be fixed after knowing the expansion ratio. The expansion ratio is generally taken as 3 : 1 (horizontal : lateral), i.e., not steeper than 22.5°. To maintain streamlined flow and also to reduce loss of head the transitions are generally made up of curved and flared wing walls.